DOCUMENT RESUME

ED 160 077 IR 006 236

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TITLE The Lister Hill Center Plasma Terminal System and Implications for Medical Networks.
PUB DATE Mar 78
NOTE 16p.; Paper presented at the Annual Meeting of the Association for the Development of Computer Based Instructional Systems (Dallas, Texas, March 1-4, 1978); For related document, see IR 006 231

EDRS PRICE MF-$0.83 Plus Postage. HC Not Available from EDRS.
DESCRIPTORS *Computer Assisted Instruction; *Computer Graphics; *Computers; Computer Storage Devices; Diagrams; Medical Education; *Networks; Programing Languages
IDENTIFIERS Health Sciences; *Microprocessing; *PLATO

ABSTRACT

The Lister Hill National Center for Biomedical Communications has supported a program to develop a Plasma Terminal System for purposes of improving the effective delivery of computer based educational materials. This system, employing recent advances in microprocessing and storage technologies, will provide new alternatives for present users of computer assisted instruction networks. This paper presents an overview of the Plasma Terminal System, and discusses some implications for medical networks. (Author)

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The Lister Hill Center Plasma Terminal System and Implications for Medical Networks

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INTRODUCTION

The Lister Hill National Center for Biomedical Communication (LHNCBC) has supported a program to develop a Plasma Terminal System (PTS) for purposes of improving the effective delivery of computer based educational materials (CBEM). This system, employing recent advances in microprocessor and storage technologies, will provide new alternatives for present users of computer assisted instruction (CAI) networks. The purpose of this paper is twofold: (I) to present an overview of the Plasma Terminal System, and (II) to discuss some implications for medical networks.

I Plasma Terminal System (PTS)

A. Overview

Within the health sciences community, there are four computer assisted instruction (CAI) languages of major interest: PLATO/TUTOR (1), Coursewriter (2), MUMPS (3,4), and PILOT (5,6). Of these, PLATO/TUTOR is unique in its support of sophisticated computer generated graphics. As a consequence, while the other languages may be accessed by standard ASCII computer terminals, PLATO/TUTOR requires a specialized PLATO terminal (7,8). A growing number of health sciences educational institutions are utilizing PLATO courseware, as well as courseware available through local and network access in other CAI languages. Hence, one objective of the Lister Hill PTS was to develop a terminal that would be able to service multiple communications protocols, including PLATO and ASCII.

Another objective was to provide a graphics capability commensurate with PLATO for other CAI languages. The problem was not only the provision of a graphics capability, but the provision of same without the normally high host computer overhead. Just how this has been achieved will be discussed in the subsequent section on Design Philosophy.

The PILOT CAI language is unique in the wide range of its implementations; from large scale computers to microprocessors and stand-alone intelligent terminal systems. LHNCBC most recently supported the implementation of PILOT on the INTEL 8080 microprocessor, as well as an extended, multi-user version of PILOT on the Data General family of computers (MicroNova to Eclipse). The PTS has been designed to support PILOT in a stand-alone mode with full graphics capability. Provision has also been made for the utilization of other stand-alone microprocessor based CAI languages (e.g., MUMPS) with the PTS. This stand-alone capability will allow users to experiment with the development of new material as well as the modification of existing material without jeopardizing the integrity of programs in the network host or incurring expensive developmental costs.

While ancillary to this discussion, LHNCBC has initiated a study of PLATO graphics commands for purposes of defining an appropriate set of graphics primitives for the PTS. An initial report is available (9). A synthesis

of the study conclusions will result in a recommendation to the community for CAI graphics language primitives to be used in conjunction with the PTS. The primitives are being defined so as to maximize the potential for translation of courseware from one CAI language to another.

B. Design Philosophy

The PTS development, from its inception, has been directed at providing a low-cost integrated terminal system capable of meeting the present, as well as future, interactive terminal requirements of existing CAI systems. As discussed earlier, PLATO is the graphics standard in the CAI environment. Therefore, the first PTS objective was to maintain compatibility with the PLATO V effort at the University of Illinois. The PLATO V concepts, however, do not directly parallel those developed for PTS. Although the PLATO V system takes advantage of the local processing power in the terminal, the latter is not intended to function in a stand-alone mode. That is, the PLATO V terminal can only operate in an on-line network environment. As discussed in An Interactive Graphics System Under MUMPS (11), existing CAI systems will require considerable modification to incorporate graphics generation into the host language. Further, most systems were not designed with the capacity to support a large number of interactive graphics terminals; and existing network environments do not provide the communications bandwidth desirable for true interactive graphics with animation. These "givens" heavily influenced the design of the PTS system.

The major emphasis during the PTS design was to maximize local processing capabilities. In order to provide a sophisticated interactive graphics system capable of functioning as a remote distributed terminal processor, to existing CAI systems, a flexible hardware/software design architecture was required. Most standard intelligent terminal systems are comprised of user input/output devices (plasma panel or CRT, keyboard, etc.) and communications hardware controlled by a single microprocessor. In the PTS, the complexity of locally generated graphics, stand-alone operation, and multiple remote computer communications protocols dictated the need for new concepts in terminal design. The software and hardware design concepts implemented in the PTS very closely parallel those presented in Principles of Interactive Computer Graphics (12) for dedicated graphics systems and Multiprocessor and Parallel Processing (13) for parallel processing systems. This design approach provides the modular framework necessary to migrate functions to dedicated microprocessor subsystems, within the PTS, as new processing/performance requirements are identified. Further, a unique protocol between the graphics primitives and the "outside world" was designed to facilitate interface to new micro/minicomputer systems.

Figure 1 provides a conceptual overview of the PTS hardware subsystems and their inter-relationships. Figure 2 shows the major software modules and their inter-relationships. It should be noted that the two microprocessors

run asynchronously as a "directly coupled system" (13). This allows the Language Processor (PILOT) to run in parallel with the Graphics Command Processor, thereby improving the overall performance. This feature will become more important as new languages and stand-alone program sophistication are added to the PTS.

This design concept will provide a new dimension to the implementation of interactive CAI systems. As can be seen from Figures 1 and 2, the PTS design provides an unusually flexible interface capability for both remote and local applications. The following features attest to the flexibility of this design:

System Features

- A stand-alone set of graphics primitives that encompass the functions of the primary PLATO graphics commands as a subset.
- PLATO V compatible.
- A Graphics Primitive Language (GP/L) that is host language independent.
- An extended PILOT interpreter which includes GP/L syntax processing.
- A remote computer interface (ASCII or EBCDIC) which includes GP/L syntax processing.
- A Diskette Operating System (DOS) capable of meeting the CBEM delivery requirements of stand-alone and distributed CAI systems.
- A GP/L processor interface to support the implementation of other microprocessor-based languages (e.g., MUMPS).
- A Download/Upload subsystem for the transfer of programs or graphics data to or from a remote computer system.
- A self-contained set of development tools for the creation, updating, and viewing of locally designed CAI programs and graphics data.
- Two classes of locally stored graphics images, (1) DOS based graphics frames for archival storage and, (2) frame buffer memory for interactive and repetitive display of DOS images.
- Locally applied transformations to frame buffer.
- A modular hardware/software design, which facilitates field upgrades and future system expansion; e.g., an arithmetic processing unit, DOS memory, and communications modules can be added as required to the existing system.

C. Development Status

There are two PTS terminals under development. The first is a breadboard unit made up of commercially available hardware with special interfaces designed to allow inter-processor communications. The breadboard is primarily a laboratory unit designed to support the software development effort. It is available for demonstration of PTS capabilities. The second is the pre-production unit, which is presently being built. The major differences between the two units are appearance, expansion capability, and DOS performance. The pre-production unit will be available in March 1978 for initial testing. Estimated cost of a pre-production terminal is:

Basic ASCII Terminal	$7200.00	(includes touch panel)
Diskette System (500k byte storage)	1200.00	(optional)
PLATO option (keyboard & modem)	500.00	
16k byte buffer memory	500.00	(for either processor)
PILOT Interpreter	300.00	(requires Diskette)
Desk enclosure	500.00	(optional)

It should be noted that these prices are estimates and are not actual quotes. Also, the present availability of plasma panels in the U.S. may impact future terminal costs. As multiple orders are placed, these costs will in all likelihood drop. A final note, the PTS design does not require the plasma panel; if a CRT output devices is desirable, a conversion could be performed at a reasonable cost on a multi-terminal buy.

II Network Implications

A. Present Alternatives

A spectrum of computer systems exist for the delivery of CBEM. These include network utilities, large scale computer-based systems, minicomputer-based systems, microprocessor-based systems, and stand-alone intelligent terminal systems. For purposes of clarity, let us consider just the two poles: network access and stand-alone intelligent terminals. Network access to a central utility provides the following three potential (theoretical) advantages:

1. access to the largest catalog of CBEM
2. access to the latest updates or revisions of CBEM
3. large scale aggregation of user statistics and comments

Existing network hosts are very emphatic on the need for user feedback to correct, improve, and maintain currency of lesson material. Hence, the importance of item 3 above.

Disadvantages of network access for the user are primarily economic and include:

1. cost of host computer usage
   (connect time plus CPU charges)

2. cost of communications
   (connect time plus characters-transmitted charge)

In network environments, "think time" on the part of the student can be very costly.

Stand-alone, intelligent terminal systems, on the other hand, offer major economic advantages insofar as, after the initial investment, no further charges are incurred by either student usage or "think time" (including coffee breaks). CBEM is available, in these stand-alone systems, via inexpensive storage media such as simple audio cassettes, or floppy disks. The disadvantages are:

1. limited material - only that on hand

2. lack of current revisions or updates

3. no large scale aggregation of student responses;

just the converse of the advantages to be derived from network access. The advantages and disadvantages of both alternatives are summarized in Figure 3.

B. Future Scenario

As seen in Figure 3, the advantages and disadvantages of network and stand-alone intelligent terminal delivery systems are mutually complementary. A recognition of this leads us to explore the possibility of combining both methodologies so as to maximize the advantages, and minimize the disadvantages. The following scenario is suggested:

1. A "master" catalog of CBEM is maintained in a network accessible environment. That is, a user may access the appropriate network host to use the material if desirable. The "master" catalog also maintains, with each lesson unit, the date of last revision.

2. A user (faculty member, librarian, or student), with a stand-alone intelligent terminal periodically accesses the "master" catalog on the network. If a desired lesson unit appears in the "master" catalog which is either not available locally, or is available but not current, the user initiates an action to "download" the program from the network host to the local storage medium on the intelligent terminal. A charge is incurred for each lesson downloaded in this fashion.

3. After completing step 2 above, the user disconnects from the network before, locally, utilizing the lesson units.

4. If the user (or organization) periodically dials back the network host, and "uploads" the student responses in order to aggregate student feedback, then a rebate will be given on the original charge for "downloading."

This scenario obviously combines the "best of two worlds." It provides the advantages of network access summarized in Figure 3, while, at the same time, minimizing the costs. LHNCBC's efforts directed at demonstrating the feasibility of the above approach is discussed in the next section.

C. Impact of PTS and Related Efforts on Medical Networks

Present implications of the PTS for network access to health sciences CBEM include:

1. need for only one terminal to access PLATO and other ASCII network nodes

2. reduction of host computer and communications costs through local processing

3. potential realization of scenario described in Section B.

Points 1 and 2 are readily apparent. The following discussion expands on point 3 above.

The basic requirements of the scenario in the previous section is an *integrated system* supporting "downloading" of lessons and "uploading" of student responses between stand-alone intelligent terminals and a host computer. It should be apparent, that the PTS has been designed with this function in mind. The PTS, itself, however, is just one part of an integrated capability under development at LHNCBC.

Complementary to the PTS, is the development of an integrated, multi-user CAI system/language (LHC-PILOT) (14,15,16) that is compatible across a whole family of computers (Data General) from the largest (ECLIPSE) to the smallest (Micro NOVA microcomputer). LHC-PILOT will also be implemented on PTS.

The LHC-PILOT system, with PTS as an integral part, is intended to demonstrate the smooth interchange of programs, data and control information in a hierarchy of processors. The LHC-PILOT system is presently under test and evaluation. Network scenarios, such as those outline above, are being developed and evaluated. The capability to "shift the load" within a CAI system provides LHNCBC designers a development tool for optimizing the network/stand-alone scenarios. Through analysis of these scenarios LHNCBC can develop recommendations for future distributed CAI system implementations. The future of distributed processing, in CAI systems, clearly rests on the ability of the system designers to distribute the computational load, in a hierarchy of processors, each optimized for its function within the overall system. The LHC-PILOT and PTS development efforts are two of LHNCBC's projects directed at demonstrating high-performance, low-cost distributed CAI delivery systems with high potential impact for medical networks.

CONCLUSIONS

The PTS described herein will allow the utilization of sophisticated computer-generated graphics with all CAI languages of interest to the health sciences community. This includes the stand-alone development and delivery of CBEM in PILOT as well as other microprocessor based languages. Every effort has been made to provide for maximum flexibility and modularity at a reasonable cost. It is expected that future improvements in the technology and an increased demand for the capabilities demonstrated in this system will serve to reduce costs even further.

The flexibility of the PTS should also allow more institutions to explore the utilization of existing CBEM without fear of early obsolescence.

ACKNOWLEDGEMENTS

Mr. Jack Stifle, University of Illinois for providing a behind-the-scenes view of the PLATO system, present and future. Mr. Stifle's support in insuring PLATO V compatibility was critical to the PTS development.

Mr. Steve Bruckner and Ms. Adrienne Kleiboemer of Mitre Corporation and Mr. Glen Chapman of Boeing Computer Services for their technical support during the PTS development. The development schedule could not have been met without their efforts.

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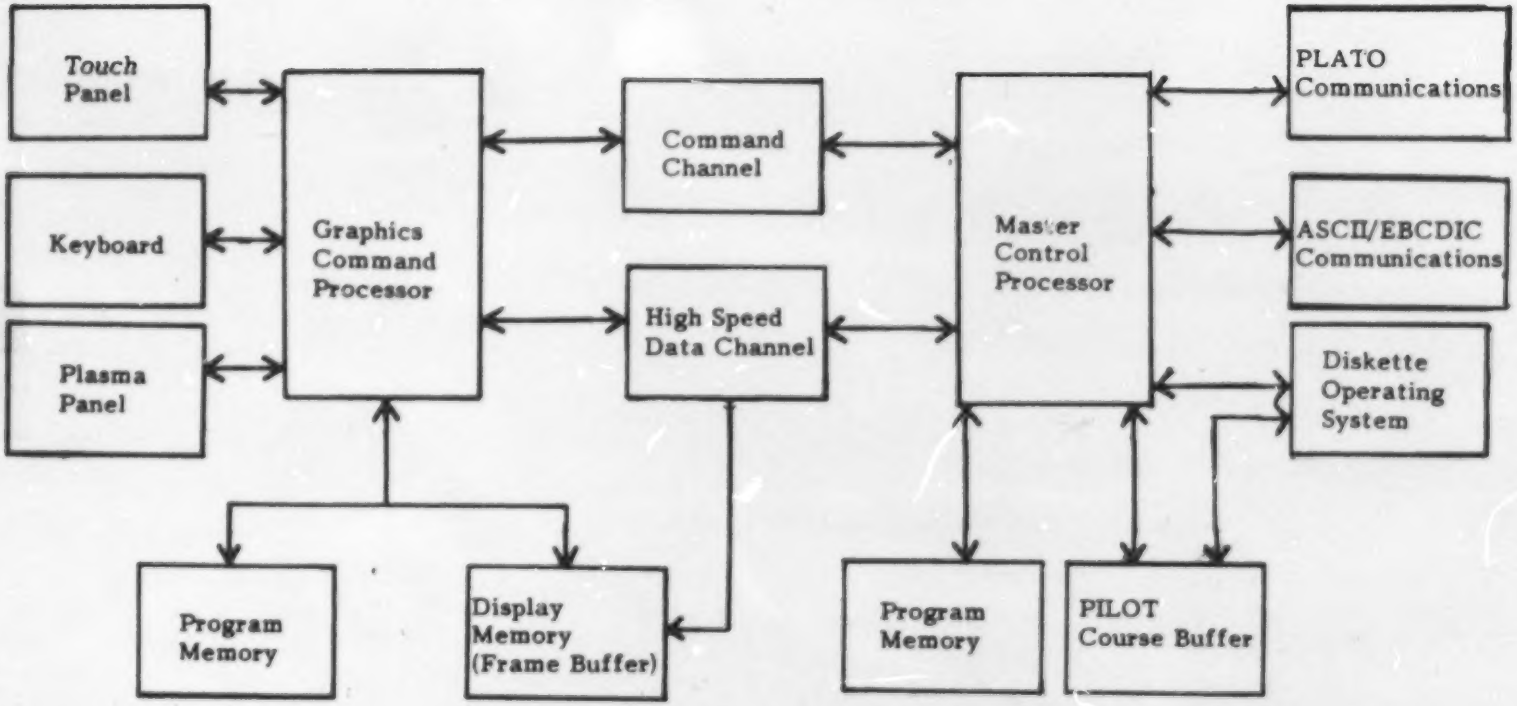
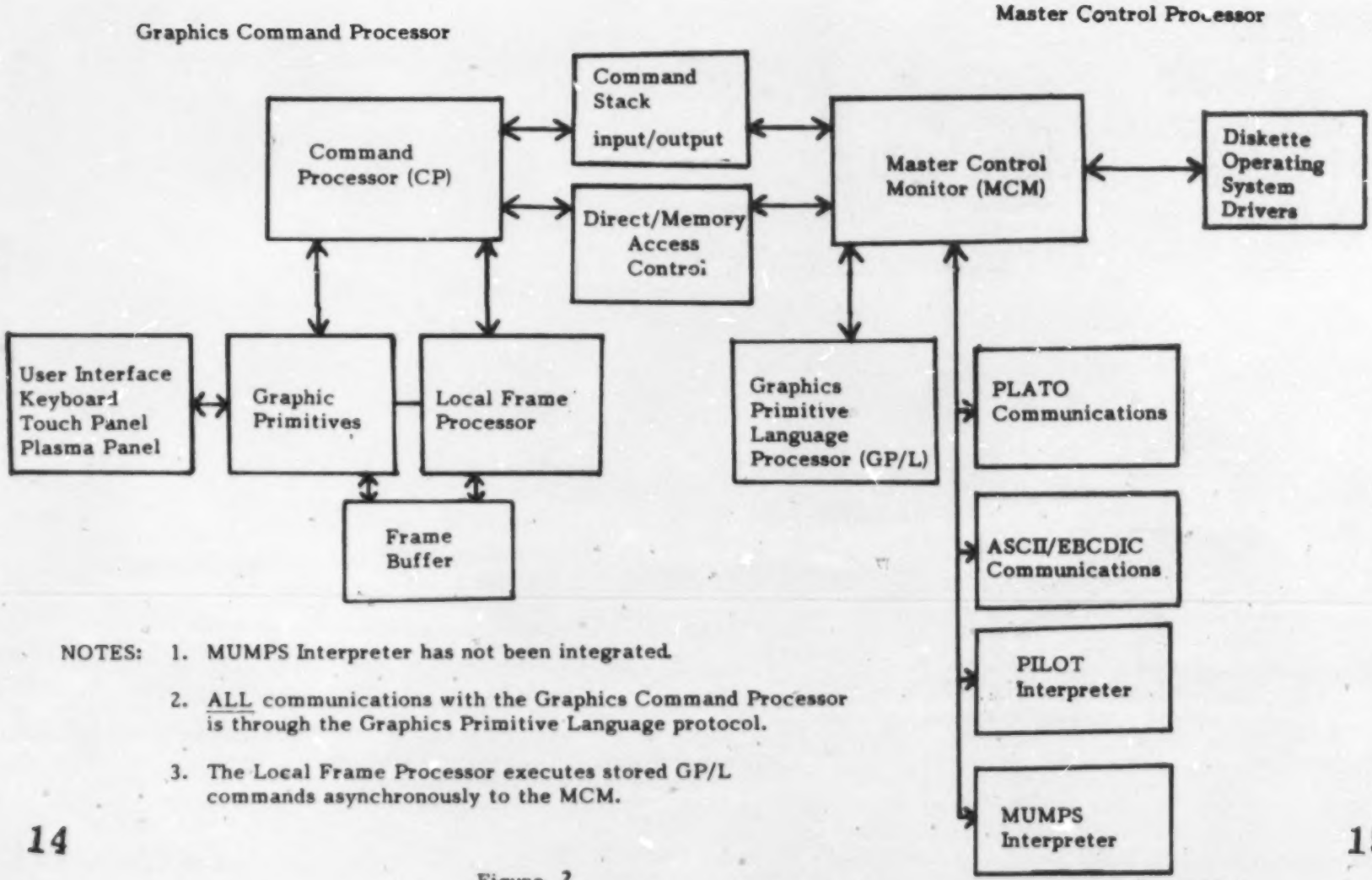
Overview of Plasma Terminal System Hardware



NOTES:
1. Both processors use direct memory access channels for high volume data transfer.
2. ALL devices/processors excluding the Plasma Panel, are interrupt driven.
3. Total memory (program and buffers) cannot exceed 64K bytes in either processor.
4. Future expansion includes a Math Processing Unit for either processor.

Figure 1.

Overview of Plasma Terminal System Software



NOTES:
1. MUMPS Interpreter has not been integrated.
2. ALL communications with the Graphics Command Processor is through the Graphics Primitive Language protocol.
3. The Local Frame Processor executes stored GP/L commands asynchronously to the MCM.

Figure 2.

	Network Access	Stand-Alone Intelligent Terminal Systems
number of available lessons	maximum	limited to those on hand
updates & revisions	current	not current
aggregation of feedback	maximum	minimum
host computer costs	yes	no
communication costs	yes	no

(unshaded areas represent relative advantages, and vice versa)

Figure 3 - SUMMARY OF ADVANTAGES & DISADVANTAGES